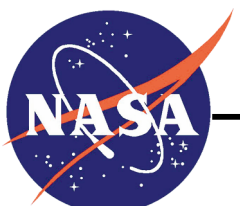
Global Precipitation Mission
Ground Validation System
Level 3 Requirements
For A Mobile
Ka-/Ku-band Radar

DRAFT
December 3, 2007

Goddard Space Flight Center
Greenbelt, Maryland 20771



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DRAFT: December 3, 2007

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DOCUMENT HISTORY

Document Version	Publication Date	Changes
Version 1	October 29, 2007	Initial Release
Version 2	November 20, 2007	Revised several existing requirements and added additional requirements based on discussion in the November 13-14 radar workshop
Version 3	December 3, 2007	Revised several existing requirements and added additional requirements based on discussion in requirements telecon on 11/30. Also separated the instrument measurements section into electrical and mechanical sub-sections.

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1. Overview

1.1 Background and Purpose

This specification defines the Level 3 functional and performance requirements for NASA's Global Precipitation Measurement (GPM) mission Ground Validation System Mobile Radar (GVSMR).

1.2 Document Scope

This document sets forth requirements for NASA's GPM GVSMR including necessary ground validation measurement, data ingest, processing, archiving, and distribution.

The structure and functional breakdown of this document are used to organize the requirements only, and should not be interpreted as a physical architecture or allocation. Physical attributes and implementation approaches of the GVSMR are intentionally omitted from this document.

The GVS requirements presented in this document are traceable to the NASA GPM Level 2 Requirements.

1.3 Applicable Documents

The following is considered the controlling documents for this specification:

- NASA GPM Project Level 1 Requirements.
- NASA Global Precipitation Measurement (GPM) Mission (L2) Requirements Document (420.2-REQS-013001A).

1.4 Document Organization

Section 1 of this document provides introduction and background information on the GVS, including an overview of the GVS and its operations. Section 2 defines the overall GVSMR requirements. Section 3 defines all symbols and acronyms. Section 4 provides a work-off plan for all items that are "to be determined" (TBD) at the time this document was written.

2. Requirements

2.1 Instrument Measurement Requirements: Ka-band and Ku-band scanning radar

2.1.1 Electrical Performance Requirements

GVSMR-2.1.05 **Ka-band scanning radar center frequency**
The GVSMR Ka-band radar shall have a center frequency that operates in the range of approximately (TBD-10) GHz.

Rationale: This is the frequency range that was allocated to HIRAP.

Validation Method: Demonstration

Priority: High

Note: the frequency range is subject to approval by NTIA.

GVSMR-2.1.07 **Ku-band scanning radar center frequency**
The GVSMR Ku-band radar shall have a center frequency that operates in the range of approximately (TBD-10) GHz.

Rationale: This is the frequency range that was allocated to HIRAP.

Validation Method: Demonstration

Priority: High

Note: the frequency range is subject to approval by NTIA.

GVSMR-2.1.10 **Scanning radar beam width**
The GVSMR shall have a full width half-power beam width of ≤1 degree.

Rationale: This is a nominal beam width for a research quality scanning radar. It permits approximately 500 m vertical resolution at a range of 30 km.

Validation Method: Analysis

Priority: This requirement may be traded against cost and other performance requirements

Note: This requirement applies to both the Ka and Ku bands.

GVSMR-2.1.11 **Matched V & H antenna patterns in Ka-band**
The GVSMR shall have Ka-band V and H antenna patterns matched to within 5% integrated power over the main lobe.

Rationale: Mixed V and H antenna gain patterns are required for generating various polarimetric products.

Validation Method: TBD-12

Priority: High

GVSMR-2.1.12 Matched V & H antenna patterns in Ku-band

The GVSMR shall have Ku-band V and H antenna patterns matched to within 5% integrated power over the main lobe.

Rationale: Mixed V and H antenna gain patterns are required for generating various polarimetric products.

Validation Method: TBD-12

GVSMR-2.1.13 Maximum Ka-band sidelobe

The GVSMR shall have a maximum Ka-band 1st sidelobe gain of -25 dB compared to the Ka-band main lobe.

Note: this requirement applies to both H and V polarization.

Rationale:

Validation Method: TBD-12

Priority: This requirement may be traded against cost and other performance requirements

GVSMR-2.1.14 Maximum Ku-band sidelobe

The GVSMR shall have a maximum Ku-band sidelobe gain of -25 dB compared to the Ku-band main lobe.

Rationale:

Validation Method: TBD-12

Priority: This requirement may be traded against cost and other performance requirements

Note: this requirement applies to both H and V polarization.

GVSMR-2.1.16 Ku-band minimum detectable signal

The GVSMR Ku-band shall have a minimum detectable signal of -10 dBZ at 30 km for a single pulse when measured with 150 m range resolution.

Rationale: any higher detectable signal will be fully attenuated in light rain

Validation Method:

Priority: This requirement may be traded against cost and other performance requirements

GVSMR-2.1.17 Ka-band minimum detectable signal

The GVSMR Ka-band shall have a minimum detectable signal of -10 dBZ at 15 km for a single pulse when measured with 150 m range resolution.

Rationale:

Validation Method:

Priority: This requirement may be traded against cost and other performance requirements

GVSMR-2.1.18 Measure and record transmit and receive gain
The GVSMR shall measure and record the transceiver gain on a 1-second integration to within 0.05 dB.

Rationale: required for monitoring radar calibration stability

Note: this requirement applies to both Ka-band and Ku-band radars.

GVSMR-2.1.19 Ka-band receiver dynamic range
The GVSMR Ka-band receiver shall have a dynamic range of ≥80 dB (TBD-13)

Rationale:

Validation Method:

Priority:

GVSMR-2.1.20 Ku-band receiver dynamic range
The GVSMR Ku-band receiver shall have a dynamic range of ≥90 dB.

Rationale:

Validation Method:

Priority:

GVSMR-2.1.21 Ka-band and Ku-band beam co-alignment
The GVSMR shall co-align the Ka-band antenna pattern with Ku-band antenna pattern to within one-tenth of the 3 dB beamwidth.

Rationale: Both radars need to sample the same volume of space at the same time.

2.1.2 Physical/Mechanical Performance Requirements

GVSMR-2.1.22 Scanning radar minimum operational range
The GVSMR shall have a minimum operational range of 100 meters when the range resolution is set to 50 meters.

Rationale: 100 m is a reasonable range for setting up a calibration target.

GVSMR-2.1.23 Scanning radar minimum range resolution
The GVSMR shall have a minimum range resolution of ≤37.5 m for all gates within the minimum and maximum range.

The GVSMR shall have a minimum range resolution of 37.5 meters.

Rationale: 37.5 m is equivalent to a 0.25 _sec pulse width.

Validation Method: Demonstration

Priority: High

GVSMR-2.1.25 Selectable radar range resolution
The GVSMR shall have a selectable range resolution from the minimum up to at least 250 m.

Note: the minimum range resolution is defined in requirement GVSM-2.1.23.

Rationale: The radar data must have sufficient resolution to provide meaningful information on the spatial variability of rainfall and other products.

GVSMR-2.1.30 Scanning radar elevation pointing resolution
The GVSMR shall have an elevation pointing resolution of <0.1 degree.

Rationale:

Validation Method:

Priority:

GVSMR-2.1.30 Scanning radar elevation pointing uncertainty
The GVSMR shall have an elevation pointing uncertainty of <0.2 degree.

Rationale: This is nominal pointing uncertainty for a research quality radar. It maintains a beam height error upper limit of ~100 m at the radar maximum range of 30 km.

Validation Method:

Priority:

GVSMR-2.1.60 Azimuth radar scan rates
The GVSMR shall provide a maximum azimuthal scan rate of at least 36° sec^{-1}.

Rationale: These rates allow the GVSMR to be scan-synchronized with any WSR-88D unit.

Validation Method: Demonstration

Priority: High

GVSMR-2.1.65 Elevation radar scan rates
The GVSMR shall provide a maximum elevation scan rate of at least 4° sec^{-1}.

Rationale: These rates allow the GVSMR to be scan-synchronized with any WSR-88D unit.

Validation Method: Demonstration

Priority: High

GVSMR-2.3.70 Scanning radar minimum and maximum elevation
The GVSMR shall have a range of elevation look angles from -0.5° to 90°.

Rationale: The stated elevation range is required for the radar to scan, as near as practical, a full 3-D volume.

Validation Method: Demonstration

Priority: High

GVSMR-2.3.75 Scanning radar azimuth range
The GVSMR shall be capable of scanning a full 360 degrees of azimuth.

Rationale: The stated elevation range is required for the radar to scan, as near as practical, a full 3-D volume.

Validation Method: Demonstration

Priority: High

2.2 Product Generation Requirements

2.2.1 Measured Products: products generated in the native coordinates of the instrument with no interpolation in time or space

GVSMR-2.2.05 Scanning radar equivalent reflectivity factor product
The GVSMR shall generate Ka-band and Ku-band calibrated horizontal and vertical equivalent reflectivity factor (Z_h and Z_v) products (in dB) to an accuracy of ≤1.0 dB for measurements at all ranges and elevations, independent of any attenuation correction.

Rationale: An accuracy of 1.0 dBZ is necessary to provide sufficient accuracy of the rain rate derived from reflectivity, and to match the reflectivity accuracy requirements of the GPM DPR.

Validation Method:

Priority: High

GVSMR-2.2.10 Scanning radar differential reflectivity product
The GVSMR shall generate Ka-band and Ku-band calibrated differential reflectivity (Z_{dr}) products (in dB) with an accuracy ≤ 0.2 dB independent of any attenuation correction.

Rationale: As in GVSMR-2.2.05, but in the native range, azimuth coordinates of the radar.

Validation Method:

Priority: High

GVSMR-2.2.15 Scanning radar differential propagation phase product
The GVSMR shall generate Ka-band and Ku-band differential propagation phase (Δ_{dp} in degrees) products with an accuracy of ≤3.0 degrees for any measurement in the entire radar scan volume where the radar signal has not been completely attenuated.

Rationale: As in GVSMR-2.2.10, but in the native range, azimuth coordinates of the radar. Differential propagation is also used to eliminate ground clutter from the scan.

Validation Method:

Priority: High

GVSMR-2.2.20 Scanning radar co-polar correlation coefficient product
The GVSMR shall generate Ka-band and Ku-band correlation coefficient products (unitless) of the horizontal and vertical return signal (Δ_{hv}) with an accuracy of ≤0.005 for any measurement in the entire radar scan volume.

Rationale: The correlation coefficient is needed in concert with other measured and derived parameters to help distinguish between precipitation types and to help eliminate ground clutter.

Validation Method:

Priority: High

GVSMR-2.2.25 Scanning radar linear depolarization ratio product (optional)
The GVSMR shall generate Ka-band and Ku-band linear depolarization ratio (LDR) products (in dB) to an accuracy of ≤1.0 dB (when averaged over distances of 1 km) for both horizontal transmit/vertical receive and vertical transmit/horizontal receive conditions for any measurement in the entire radar scan volume.

Note: the default mode of data collection for the GVSMR will be simultaneous transmission and simultaneous reception (STSR) and depolarization information will not be collected. As required, the GVSMR shall operate in a mode capable of measuring the depolarization ratio (e.g., simultaneous transmit alternate reception – STAR mode).

Rationale: LDR is a good indicator of regions where a mixture of precipitation types occur and can be used as a hydrometeor identification discriminator.

Validation Method:

Priority: High

GVSMR-2.2.30 Scanning radar Doppler radial velocity product
The GVSMR shall generate Doppler radial velocity products (in m/sec) with an uncertainty of +/- 1 m/sec for any measurement in the entire radar scan volume.

Rationale: Single or multiple Doppler wind retrievals will be used to validate CRM kinematic structure.

Validation Method:

Priority: High

GVSMR-2.2.32 Zenith radar Doppler radial velocity product
The GVSMR shall generate Doppler radial velocity products (in m/sec) with an uncertainty of +/- 1 m/sec for measurements in the zenith direction.

Rationale:

Validation Method:

Priority: High

GVSMR-2.2.33 Scanning radar Doppler spectra product
The GVSMR shall generate Doppler spectra <<spec needed>>.

Rationale:

Validation Method:

Priority: High

GVSMR-2.2.34 Unambiguous velocity requirement
<<spec needed>>

Rationale:

Validation Method:

Priority: High

2.2.2 GVSMR Derived Products: products that are interpolated in time or space and/or are based on additional assumptions

GVSMR-2.2.35 Scanning radar product Cartesian grid
The GVSMR shall generate Ka-band and Ku-band radar products (defined below) interpolated from polar coordinates to a 3-dimensional Cartesian grid with, at a minimum, the following characteristics:

a. Cartesian grid center located on the scanning radar
b. Cartesian grid extending 30 km in the X,Y (east-west ,north-south) direction from the location of the radar
c. Cartesian grid extending in the Z (vertical) direction from 0.5-18km above ground level

d. Resolution of the Cartesian grid in all dimensions not to exceed the actual radar beam resolution at maximum horizontal range.

Rationale: The radar components need to be mapped to a Cartesian grid, since the original polar-coordinate product data are incompatible with requirements for use of the data. The 3-D Cartesian gridded data will be used as input to Satellite Simulation Models (SSM), for validation of Cloud Resolving Models (CRM), and to evaluate the calibration and attenuation correction of the satellite-borne PR/DPR. The domain and resolution of the 3-D grid are driven by the radar characteristics, sampling theory, and product usage.

Validation Method: Demonstration

Priority: High

GVSMR-2.2.40 Re-sampled equivalent reflectivity factor product

The GVSMR shall generate Ka-band and Ku-band resampled horizontal and vertical equivalent reflectivity factor (rZ_h and rZ_v in dB) products with, at a minimum, the following characteristics:

a. The rZ_h and rZ_v product shall be resampled to the Cartesian grid defined in Requirement GVSMR-2.2.35 for each PPI-volume scan of radar data

b. The rZ_h and rZ_v product shall have an accuracy of 2.0 dB or better for any grid element in the entire resampled radar scan volume.

Rationale: See GVSMR-2.2.05. Primarily, GVSMR reflectivity will be compared to satellite radar reflectivity on a common grid to validate the calibration of each instrument and the effectiveness of the PR/DPR attenuation corrections. It will also be used in computation of rain rates using the traditional Z-R as well as polarimetric relationships. 2 dB is the minimum accuracy required for these purposes.

Validation Method: Demonstration for 2.2.40a, analysis for 2.2.40b.

Priority: High

GVSMR 2.2.45 Re-sampled differential reflectivity product

The GVSMR shall generate Ka-band and Ku-band resampled differential reflectivity factor (rZ_{dr} in dB) products with, at a minimum, the following characteristics:

a. The rZ_{dr} product shall be resampled to the Cartesian grid defined in Requirement GVS-2.2.35 for each PPI-volume scan of radar data.

b. The rZ_{dr} product shall have an accuracy of 0.4 dB or better for any grid element in the entire resampled radar scan volume.

Rationale: See GVSMR-2.2.10. Differential reflectivity is needed to estimate Drop Size Distributions, detect the presence of hail, and estimate rainfall using polarimetric parameters.

Validation Method: Demonstration for 2.2.45a, analysis for 2.2.45b.

Priority: High

GVSMR-2.2.50 Specific differential phase product

The GVSMR shall generate Ka-band and Ku-band differential phase (K_{dp} in degrees/km) products with, at a minimum, the following characteristics:

a. The K_{dp} product shall be measured in polar coordinates with an accuracy of 0.3 degrees/km or better over a minimum distance of 3 km for any measurement in the entire radar scan volume where reliable differential propagation phase measurements can be obtained

b. The K_{dp} product shall be generated in polar coordinates re-sampled to the Cartesian grid specified in requirement GVS-2.2.35.

Rationale: See GVSMR-2.2.15. Differential phase is needed to estimate rainfall intensity and accumulation, especially in the presence of hail. It is highly immune to radar calibration errors and partial beam blockage

Validation Method: Demonstration for 2.2.50b, analysis for 2.2.50a.

Priority: High

GVSMR-2.2.55 Liquid water content profiles

The GVSMR shall have the ability to generate estimates of the vertical profile of atmospheric precipitation liquid water content (g/m^3). Such a product will have at a minimum, the following characteristics:

a. the liquid water content product shall have a vertical resolution of ≤1 km below a height of 2km AGL and TBD-9 km above a height of 2 km AGL

b. the liquid water content product shall have temporal resolution of ≤ 15 minutes

c. the liquid water content product shall have an accuracy of TBD-8.

Rationale: Vertical profiles of atmospheric liquid water are needed as input to and validation of SSMs, and for validation and initiation of Cloud-system Resolving Models (CRMs). These data will supplement moisture profiles collected by upper air soundings. Accuracies are based on the instrument measurement requirements. Temporal resolution is the minimum required to provide a representative measurement in changing atmospheric conditions.

Validation Method: Demonstration for 2.2.55a, and 2.2.55b, analysis for 2.2.55c.

Priority: High

GVSMR-2.2.60 Scanning radar hydrometeor identification product

The GVSMR shall have the ability to estimate hydrometeor types with the subsequent product having at a minimum, the following characteristics:

a. The hydrometeor type product shall generate estimates of the most likely hydrometeor types sampled to a 3-dimensional grid with a horizontal resolution not to exceed the actual radar beam resolution for each PPI-volume scan of radar data

b. The hydrometeor type product shall classify hydrometeors into at least the following types: light rain, moderate rain, heavy rain, rain mixed with precipitation-sized ice, and precipitation-sized ice only (warm season) and low density snow, high density snow, and mixed precipitation (cold season).

Rationale: Knowledge of actual hydrometeor types is needed to model and validate microwave precipitation retrievals and CRM microphysics, and improve active radar attenuation algorithms.

Validation Method: Demonstration.

Priority: High.

GVSMR-2.2.65 Scanning radar median drop diameter product

The GVSMR shall generate a median drop diameter D_0 product (in mm) with, at a minimum, the following characteristics:

a. The D_0 product shall be sampled to a 3-dimensional grid with a horizontal resolution not to exceed the actual radar beam resolution for each PPI-volume scan of radar data

b. The D_0 product shall have an accuracy of $\leq$0.2 mm.

Rationale: See GVSMR-2.2.45. This requirement, along with GVSMR-2.2.70 and GVSMR-2.2.75 are related and interdependent. D_0 in combination with number concentration of liquid droplets (GVSMR-2.2.75) is needed to make accurate determination of rain rates from radar and to compute attenuation estimates.

Validation Method: Demonstration for 2.2.65a, analysis for 2.2.65b.

Priority: High

GVSMR-2.2.70 Scanning radar instantaneous rain rate product

The GVSMR shall generate a rain intensity product (in mm/hr) with, at a minimum, the following characteristics:

a. The rain intensity product shall be sampled to a 3-dimensional grid with a horizontal resolution not to exceed the actual radar beam resolution for each PPI-volume scan of radar data

b. The rain intensity product shall have an accuracy of ±20%.

Rationale: See GVSMR-2.2.65. Rain rate is the primary measured element to be validated in GPM. Rain rate estimates from scanning radar will be one of the validating measurements.

Validation Method: Demonstration for 2.2.70a, analysis for 2.2.70b.

Priority: High

GVSMR-2.2.75 Scanning radar number concentration – liquid product

The GVSMR shall generate a precipitation drop number concentration product that estimates of the number of liquid water drops per volume (in m^{-3}) with, at a minimum, the following characteristics:

a. The drop number concentration product shall be sampled to a 3-dimensional grid with a horizontal resolution not to exceed the actual radar beam resolution for each PPI-volume scan of radar data

b. The drop number concentration product shall have an accuracy TBD-2.

Rationale: See GVSMR-2.2.65

Validation Method: Demonstration for 2.2.75a, analysis for 2.2.75b.

Priority: High

2.3 General Requirements

GVSMR-2.3.10 Ready for operations

The GVSMR shall be ready for operations in time for the Intensive Operations Period (IOP) of the joint NASA-DOE Midlatitude Continental Convective Clouds Experiment (MC^3E).

Rationale: MC^3E is the next scheduled GPM GV campaign.

Validation Method: Demonstration.

Priority: Delivery data can be traded against cost.

Note: The current schedule calls for MC^3E to be held April-June 2010.

GVSMR-2.3.15 Operations lifetime
The GVSMR shall operate for the minimum required lifetime of the GPM Core and Constellation Satellites.

GVSMR-2.3.17 Availability
The GVSMR shall have an availability of at least 95% during normal operations.

Rationale:

GVSMR-2.1.70 Communications
The GVSMR shall generate quick-look images at least every 15 minutes and these images will be available to other computers in the local network.

Note: These images will show low-level Plan Position Indicators (PPIs) of radar reflectivity, differential reflectivity, and specific differential phase.

Rationale: An image display generation capability is necessary to locally and remotely monitor the instrument data quality and for weather situational awareness in GV field operations.

Validation Method: Demonstration

Priority: High

GVSMR-2.3.20 Mobility
The GVSMR shall be a transportable, self contained system capable of traveling from one field site location to another on demand.

GVSMR-2.3.25 Set up
The GVSMR shall be capable of performing full operations within 72 hours of delivery to a field site.

GVSMR-2.3.30 Tear down
The GVSMR shall be capable of transitioning from operations to a state ready for transport given 72 hours of prior notification.

GVSMR-2.3.33 Thermal Regime
The GVSMR shall operate in a range of ambient temperatures from +40 C to -40 C.

Rationale: These are the range of temperatures expected during field campaigns held in Finland in the winter and Oklahoma in the summer.

GVSMR-2.3.34 Wind load
The GVSMR shall operate in a range of wind velocities up to a maximum of TBD-14 m/sec.

Note: this requirement applies to both Ka-band and Ku-band radars.

Rationale:

GVSMR-2.3.35 Precipitation regime
The GVSMR shall be capable of operations in rain of up to 15 mm per hour, snow of up to 4 cm per hour, and freezing rain .

Note: this requirement applies to both Ka-band and Ku-band radars.

Rationale:

GVSMR-2.3.36 MPG metrics capability
The GVSMR shall, at a minimum, monitor and record

a. ground instrument up time, outage and/or malfunction

b. others metrics TBD-1.

GVSMR-2.3.40 Unattended operations (TBD-2)
The GVSMR shall be capable of unattended operations with, at a minimum, the following capabilities:

a. the ability to operate the radar from a remote location via electronic networks, including the ability to modify and execute scan sequences from remote locations

b. the ability to distribute a selectable list of products in near-real-time over electronic networks

c. the ability to operate autonomously (without human support or intervention) for a minimum of 72 hours

d. the ability to transmit notifications to selected destinations in the event of non-nominal conditions.

GVSMR-2.3.45 Check validity of data recorded
The GVSMR shall perform automated verification of data formats and ranges for all data recorded.

GVSMR-2.3.50 Check validity of data distributed
The GVSMR shall perform automated verification of data formats and checksums on all data distributed.

GVSMR-2.3.55 Observe MAR, NPRs, and GPRs
The GVSMR shall observe all applicable NASA/GSFC Mission Assurance Requirements (MAR), NASA Program Requirements (NPRs) and Goddard Program Requirements (GPRs).

GVSMR-2.3.60 Conduct pre-operational testing
The GVSMR shall support pre-operational testing.

GVSMR-2.3.65 Conduct maintenance and sustaining engineering
The GVSMR shall conduct maintenance and sustaining engineering throughout the period of GVS operations.

GVSMR-2.3.70 Conduct configuration management
The GVSMR shall maintain configuration control, at a minimum over

a. Internal systems and software

b. Data holdings, including products, reports, documentation and computer code

c. External interfaces.

GVSMR-2.3.75 Safety
The GVSMR shall ensure the safety of all system elements and personnel.

GVSMR-2.3.80 Interface to GVS Archive and Distribution Element
The GVSMR shall provide all data, including products, reports, documentation and computer code to the GVS Archive and Distribution Element.

GVSMR-2.3.85 Interface to Precipitation Processing System (TBD-3)
The GVSMR shall receive GPM overpass schedules from the Precipitation Processing System.

GVSMR-2.3.90 Local archive capability
The GVSMR shall implement a local archive capability. The local archive capability shall

a. maintain the integrity of all data collected

b. manage multiple versions of the same data.

GVSMR-2.3.95 Instrument updates
The GVSMR shall permit the introduction of new or updated hardware on an as needed basis.

GVSMR-2.3.100 Software updates
The GVSMR shall permit the introduction of new or updated system software.

GVSMR-2.3.105 Generation of measured products
The GVSMR shall generate measured products within 24 hours of observations during nominal operations.

Note: See section 2.2.1 for a definition of a “measured product."

GVSMR-2.3.110 Generation of derived products
The GVSMR shall generate derived products within TBD-5 hours of receipt of required input observations during nominal operations.

Note: See section 2.2.2 for a definition of a derived product.

GVSMR-2.3.115 Data format
The GVSMR shall generate data products that conform to at least one standard science data format.

Note: netCDF is a science data format that is commonly used by the atmospheric sciences community.

Rationale: Use of a standard data format will increase the ease of use of the radar data.

GVSMR-2.3.120 Interface to standard analysis and display tools
The GVSMR shall generate data products that can be used directly by Sigmet IRIS.

Rationale: Sigmet IRIS is a commonly used radar data analysis and display package.

GVSMR-2.3.125 Commercial electrical power
The GVSMR shall be capable of operations from commercial power sources, including those with the following characteristics:

c. single or 2-phase

d. 100 V to 240 V

e. 50 Hz or 60 Hz.

Rationale: The radar may operate in the US or internationally and may encounter a variety of commercial power sources.

GVSMR-2.3.130 Electrical generator
The GVSMR shall have the ability to generate sufficient electrical power to meet all of its autonomous operational requirements.

Rationale: The radar may operate in the US or internationally and may encounter situations where no commercial power source is available.

3. Acronyms and Symbols

ACRONYM	DEFINITION
3-D	3-Dimension
AGL	Above Ground Level
CM	Configuration Management
CMO	Configuration Management Office
CRM	Cloud Resolving Model
D_0	Median drop diameter
dB	Decibel
dBZ	Reflectivity in decibels
DOE	Department of Energy
DPR	Dual-frequency Precipitation Radar
DSD	Drop Size Distribution
g	gram
GHz	GigaHertz
GMI	Global Microwave Imager
GPR	Goddard Project Requirement
GPM	Global Precipitation Measurement
GSFC	Goddard Space Flight Center
GV	Ground Validation
GVS	Ground Validation System
GVSMR	Ground Validation System Mobile Radar
HIRAP	
hr	Hour
IOP	Intensive Operations Period
IFOV	Instantaneous Field of View
K_{dp}	Specific Differential Phase
km	kilometer
LDR	Linear Depolarization Ratio
m	Meter
MAR	Mission Assurance Requirements
MC^3E	Midlatitude Continental Convective Clouds Experiment
mm	Millimeter
ms^{-1}	Meters per second
NASA	National Aeronautics and Space Administration
NITA	
NPR	NASA Program Requirement
PMM	Precipitation Measuring Missions
PPI	Plan Position Indicator
PR	Precipitation Radar
QC	Quality Control
rZ_{dr}	Resampled differential reflectivity factor
rZ_h	Resampled equivalent reflectivity factor horizontal polarization

rZ_V	Resampled equivalent reflectivity factor vertical polarization
s, sec	Second
SSM	Model-Based Analysis
STSR	Simultaneous Transmission and Simultaneous Reception
STAR	Simultaneous Transmission Alternate Reception
TBD	To Be Determined
WSR-88D	Weather Surveillance Radar - 1988 Doppler
Z	Reflectivity Factor
Z-R	Reflectivity Factor-Rain
Z_{dr} (rZ_{dr})	Differential reflectivity factor (resampled)
Z_h (rZ_h)	Equivalent reflectivity factor horizontal polarization (resampled)
Z_V (rZ_V)	Equivalent reflectivity factor vertical polarization (resampled)
_dp	Differential propagation phase
_vh	Correlation coefficient of the horizontal and vertical return signal

4. Work-off Items

Item No.	Description
TBD-1	Metrics to be recorded by GVSMR
TBD-2	Maybe more detail is needed to define what unattended operations means
TBD-3	Is it necessary to specify this interface?
TBD-4	CLOSED
TBD-5	Time-line for delivery of derived products
TBD-6	CLOSED
TBD-7	CLOSED
TBD-8	Accuracy of the liquid water content product.
TBD-9	Vertical resolution of liquid water profile product
TBD-10	Jim Carswell to provide the allocated Ka frequency range for DPR
TBD-11	Jim Carswell to provide the allocated Ku frequency range for DPR
TBD-12	Validation method for Ka and Ku band antenna pattern
TBD-13	Chandra to verify the spec on the Ka and Ku dynamic range
TBD-14	maximum wind velocity operations specification